U.S. Department
of Transportation

**Federal Aviation
Administration**

Advisory Circular

SHOCK ABSORPTION TESTS	**Date:** **Initiated by: ANM-110**	**AC No. 25.723-1** **Change:**

1. PURPOSE. This advisory circular (AC) sets forth an acceptable means, but not the only means, of demonstrating compliance with the provisions of part 25 of the Federal Aviation Regulations (FAR) related to the use of landing gear shock absorption tests and analyses to determine landing loads for transport category airplanes.

2. RELATED FAR SECTIONS. Part 25, Section 25.723 "Shock absorption tests" and Section 25.473 "Ground load conditions and assumptions."

3. BACKGROUND. The requirement concerning energy absorption tests for landing gear units existed in the earliest versions of the Civil Aeronautics Regulations (CAR) Part 04. Questions concerning the need for the tests and the use of analyses in lieu of tests have existed since the CAR 04 and have resulted in revisions to the successor regulations CAR 4b, which replaced CAR 04, and later in the Federal Aviation Regulation (FAR), Part 25, which replaced CAR 4b.

a. Section 04.34 of CAR 04 (July 1944) allowed analyses in lieu of tests when the landing gear structure conformed to conventional types for which reliable analytical methods were available. With the advancing complexity of landing gear units, the rule was revised (CAR 4b, Section 4b.332) to require energy absorption tests to determine the landing load factors both at maximum landing weight and maximum takeoff weight. Although this rule did not specifically provide for analyses in lieu of tests, it was common practice to allow later changes in design weights to be substantiated by analytical methods which were validated by the results of the earlier tests.

b. Recognizing the need to provide for subsequent growth in the design weights, the Federal Aviation Administration (FAA) revised § 25.723 (Amendment 25-46) to clarify that analyses could be used to substantiate changes in the takeoff and landing weights provided these analyses were validated by the results of tests conducted on identical landing gear units.

c. Although the rule referred to tests on the "identical" landing gear units, subsequent changes in the design weights often are accompanied by minor changes in other parameters affecting the landing gear energy absorption characteristics. These included changes in the shock absorber orifice size and metering pins shape, and changes in tire inflation limits. The FAA revised § 25.723 (Amendment 25-72) to further clarify that the analyses could be based on tests performed on the same basic landing gear system with similar energy absorption characteristics.

d. In the mean time, other requirements have resulted in changes in the way the test and analytical data are used. The shock absorption tests are no longer used just to determine the landing load factors. It is now necessary to account for dynamic landing conditions in which the dynamic characteristics of the airplane and landing gear acting together are used to determine the landing loads. As a practical matter, the analytical modeling of the landing gear dynamic characteristics is indispensable in determining the landing loads, and the shock absorption tests are needed in order to validate the mathematical modeling of the landing gear units.

4. SHOCK ABSORPTION TESTS.

a. Validation of the landing gear characteristics. Shock absorption tests are necessary to validate the analytical representation of the dynamic characteristics of the landing gear unit that will be used to determine the landing loads. A range of tests should be conducted to ensure that the analytical model is valid for reasonable extrapolations to other design conditions and configurations expected in service. In addition, consideration should be given to ensuring that the range of test configurations are sufficient for justifying the analytical model for foreseeable future growth versions of the airplane.

b. Recommended test conditions for new landing gear units. The maximum takeoff weight and the maximum landing weight conditions should both be included as configurations subjected to energy absorption tests. However, in cases where the manufacturer has previous experience in validating the analytical model using landing gear units of similar design concept, it may be sufficient to conduct a single shock absorption test of the new landing gear for the condition associated with maximum energy. The similar landing gear used to provide the additional supporting data may be from another model aircraft but the landing gear unit should be of approximately the same size with similar components.

c. Changes to type designs. Subsequent changes to the landing conditions or to the landing gear units may be substantiated by analyses based on tests of the same basic landing gear unit with similar dynamic characteristics, provided the design concept has not changed and the results of the previous energy absorption tests are sufficient to realistically validate the analytical results for the design changes. For example, the following changes may be acceptable without further tests:

(1) Airplane sprung mass (effective weight) variations, including extrapolation from maximum landing weight to maximum take-off weight conditions.

(2) Changes in shock absorber characteristics including pre-load, compression ratio, office sizes.

(3) Changes in tire characteristics.

(4) Changes in unsprung mass (e.g. brakes).

(5) Local strengthening or minor sizing changes to the landing gear.

5. <u>LIMIT FREE DROP TESTS.</u>

(a) Compliance with § 25.723(a) may be shown by free drop tests, provided they are made on the complete airplane, or on units consisting of a wheel, tire, and shock absorber, in their proper positions, from free drop heights not less than--

(1) 18.7 inches for the design landing weight conditions; and

(2) 6.7 inches for the design takeoff weight conditions.

(b) If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by a reduced mass, the landing gear must be dropped with an effective mass equal to

$$W_e = W\left[\frac{h+(1-L)d}{h+d}\right]$$

where—

W_e = the effective weight to be used in the drop test (lb);
h = specified free drop height (inches);
d = deflection under impact of the tire(at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass (inches);
W = W_M for main gear units (lb), equal to the static weight on that unit with the airplane in the level attitude (with the nose wheel clear in the case of nose wheel type airplanes);
W = W_T for tail gear units (lb), equal to the static weight on the tail unit with the airplane in the tail-down attitude;
W = W_N for nose wheel units (lb), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0 *g* downward and 0.25 *g* forward; and
L = ratio of the assumed airplane lift to the airplane weight, but not more than 1.0.

(c) The drop test attitude of the landing gear unit and the application of appropriate drag loads during the test must simulate the airplane landing conditions in a manner consistent with the development of a rational or conservative limit loads.

(d) The value of d used in the computation of W_e in paragraph (b) of this section may not exceed the value actually obtained in the drop test.

6. <u>RESERVE ENERGY FREE DROP TESTS.</u>

(a) Compliance with the reserve energy absorption condition specified in § 25.723(b) may be shown by free drop tests provided the drop height is not less than 27 inches.

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$$W_e = \frac{Wh}{h+d}$$

where the symbols and other details are the same as in paragraph 5 above.